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Some Characteristics of Satellite-Observed Bands Of Persistent Cloudiness Over the Southern Hemisphere

NEIL A. STRETEN[1]—*Commonwealth Meteorology Research Centre Melbourne, Victoria, Australia*

ABSTRACT—An analysis is made of the annual and seasonal frequency of location and movement of maximum brightness (cloudiness) bands of substantial extent appearing on the Southern Hemisphere 5-day-averaged satellite data; the possible relation of such bands to the hemispheric long-wave pattern is discussed. The number of bands over the hemisphere for a particular 5-day period varies with latitude and season, but a high frequency of 3–4 is observed at midlatitudes in all months. Three years of averaged data indicate that the location of high band frequency is largely stable in the Pacific and Atlantic Oceans but that the Indian Ocean displays higher frequencies to the west in summer and to the east in winter. Longitudinal displacement of bands between successive 5-day periods varies to some degree with season, but only little with latitude. It is least and most symmetric in the South Atlantic, but elsewhere it is predominantly eastward with a peak frequency of 5°–10° of longitude per period. Some evidence exists for a longer term westward trend in the location of the Pacific band from mid 1969 to mid 1971. The frequency of 5-day-averaged cloud bands is in qualitative agreement with patterns of rainfall over Australia in specific winter and spring seasons and points to qualitative assessment of broad patterns of oceanic rainfall.

1. INTRODUCTION

Features of both daily and multiday averages of brightness recorded by satellite cameras and radiometers and depicted on global digital maps (Booth and Taylor 1969, Leese et al. 1970) are the prominent bright bands extending either predominantly zonally or meridionally in particular geographic locations. Such bands are most clearly defined over the oceans and, in the case of nonzonal orientations, particularly over the Southern Hemisphere, where the bands frequently extend to high latitudes.

Recent analyses of the zonally oriented banding in the Tropics (Gruber 1972) has revealed aspects of the behavior of the intertropical convergence zone (ITCZ), and Saha (1971) has drawn attention to the apparent association between the tropical cloud bands and ridges of sea-surface temperature. Further, Erickson and Winston (1972) have examined the relation between cloud bands extending from tropical storms poleward into the Northern Hemisphere westerlies and the increase in the strength of the planetary circulation in autumn. They suggest that these particular bands visually depict channels for the transfer of energy in the form of heat and moisture from the tropical storms to midlatitudes.

2. CLOUD BANDS AND THE LONG-WAVE PATTERN OF THE SOUTHERN HEMISPHERE

Extratropical bright bands on daily pictures represent either frontally organized clouds usually associated with a cyclonic cloud vortex at middle or high latitudes or, alternatively, an elongated region of low or midtropospheric convergence frequently lying between midlatitude anticyclones. When viewed on averaged photographs over a number of days, the banding is related to the persistence of particular features or to repetitive events in the same location. Examination of Southern Hemisphere mosaics (e.g., Streten 1968*b*) indicates that the averaged bright banding at middle to high latitudes is due to a considerable regularity in the tracks of depressions, to the persistence of convergence in particular locations, or to a combination of both factors.

If the bands are primarily related to these features, synoptic experience suggests that they should be located close to, though probably eastward of, the upper long-wave troughs in the lower troposphere. Staver (1969) found that clouds over the southern oceans in summer formed primarily ahead of the 700-mb trough, where warm air is being advected over relatively cool water. After a rapid transition in autumn, however, clouds in other seasons were found largely behind the trough, where cold outbreaks occur over relatively warm water. Some doubt is expressed, however, as to whether these results are entirely representative and whether they can be applied to 5-day-averaged cloud amounts.

The upper wave pattern in the middle and high southern latitudes revealed by mean monthly or seasonal data does not exhibit well-defined troughs or ridges (Lamb 1959, Taljaard et al. 1969). However, a recent analysis of the zonal harmonic standing waves over the hemisphere using surface and upper data for the IGY (van Loon and

[1] Now at the Geophysical Institute, University of Alaska, Fairbanks, Alaska

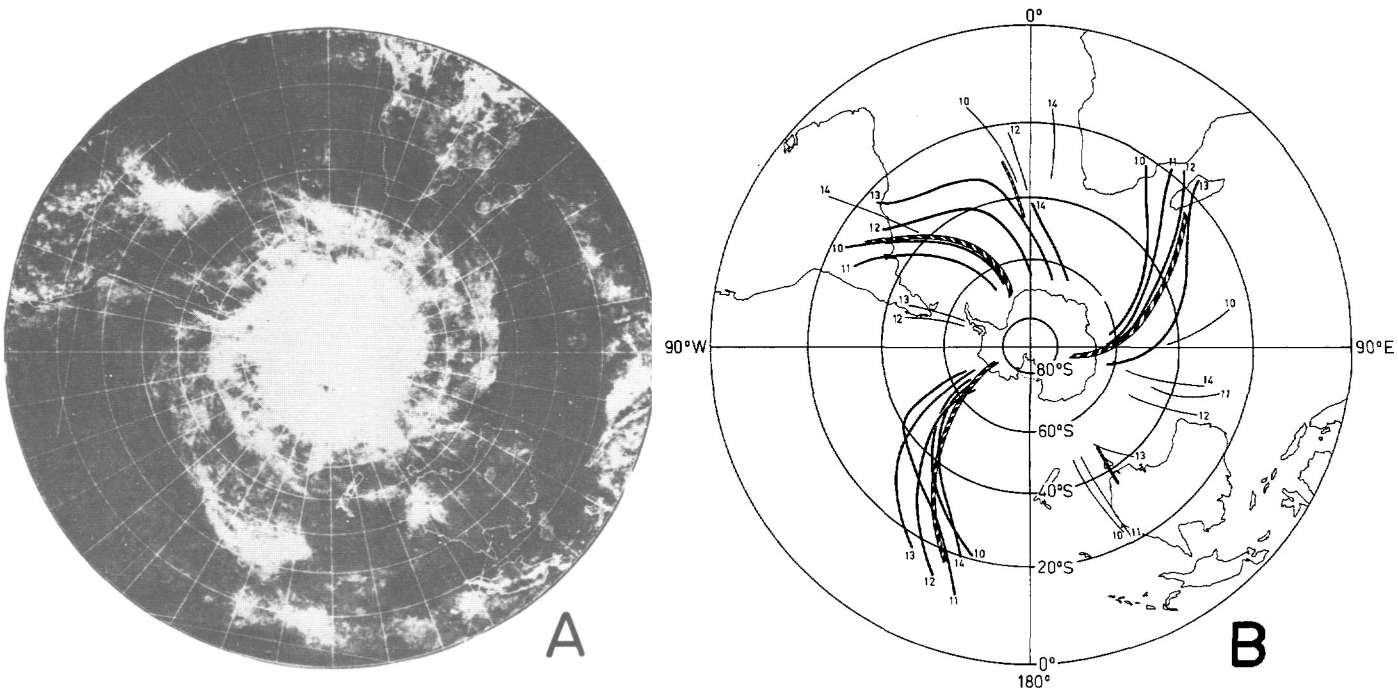

FIGURE 1.—(A) 5-day-averaged mosaic Nov. 10–14, 1969 and (B) location of 700-mb troughs in the long-wave, scale-separated components for corresponding indicated dates. Heavy lines represent well-defined troughs, fine lines represent minor troughs, and striped lines represent troughs in the mean 5-day field.

Jenne 1972) has revealed that waves 1 and 3 have significant standing components, and that wave number 3 is particularly prominent between latitudes 40° and 60°S with ridges near the three low-latitude continents. Further inferences to frequently occurring maxima and minima of trough and ridge frequency may be obtained by study of 5-day means of pressure and geopotential derived from synoptic chart series (e.g., Noar 1973) by a statistical procedure using multiple regression with specific cloudiness indices to estimate 700-mb heights around particular latitude circles (Staver 1969), and by inference from the pattern of formation and movement of satellite-observed cloud vortexes associated with depressions (Streten 1968*a*, Streten and Troup 1973).

Techniques for the separation of so-called inherent scales (Holl 1963*a*, 1963*b*, Riegel 1965) enable realistic approximations to the long-wave field to be obtained from individual synoptic charts for cases where high-quality basic analyses are available. The smoothing is defined by

$$Z_{LW}=Z_o+C\int_0^{\alpha}\nabla^2 Z d\alpha=Z_o-Z_{SW}$$

where Z_{LW} is the long-wave field, Z_o is the original field, Z_{SW} is the short-wave field, C is a constant, and α is a parameter representing the degree of smoothing.

An example of this technique is shown in figure 1 for a 5-day period (Nov. 10–14, 1969) when an optimum observational distribution for the first Global Atmospheric Research Program (GARP) project was available and when a reasonably well-defined cloud band pattern was evident on the 5-day-averaged hemispheric mosaic. A third-order smoothing program modified from that of Nagle and Hayden (1971) was employed using $\alpha=3$ for an N23 grid (i.e., 23 points between the Equator and the pole). This results in a 90-percent short-wave amplitude reduction for zonal wave numbers greater than 7 at 60°S. Five individual, and an average of the five long-wave scale-separated 700-mb, patterns were obtained from the 0000 GMT daily analyses. In this test case, the prominent cloud bands are generally located close to or slightly eastward of well-defined groups of 700-mb long-wave troughs occurring in the daily scale separated fields.

To obtain a seasonal statistical relationship between the position of the scale-separated long-wave troughs and the band axes, one would need a substantial series of high-quality gridded charts for the hemisphere coincident with suitable 5-day-averaged pictures—a situation not yet realized in practice. However, synoptic experience and the evidence presently available suggest that there is a close, though not necessarily unique, association between the cloud bands and the configuration of the upper long-wave pattern.

The high frequency of the extratropical banding over the Southern Hemisphere and the frequent apparent spatial continuity from period to period in the 5-day-averaged mosaic sequences is notable. This suggests that examination of the band sequences (which are themselves of practical interest) may reveal features of the hemispheric circulation and its temporal variations. The bands may thus act as markers of the broad-scale circulation features over the data-void southern oceans.

3. HEMISPHERIC CLOUD BAND DATA

The data employed in the investigation of the bands were the 200 5-day-averaged brightness mosaics covering the Southern Hemisphere for 1,000 days of a 3-yr period (November 1968–October 1971). The source satellites for the period were ESSA 7, ESSA 9, ITOS 1, and NOAA 1. The mosaics varied in quality and degree of continuity throughout the period and were only of limited value in winter at latitudes higher than 40°S. The pictorial data are not strictly comparable from one period to another. On individual mosaics, however, the regions of maximum and minimum brightness can usually be reliably distinguished, and a geometric axis can be delineated for each organized band that is bright in relation to the surrounding areas of the mosaic.

To be included in the statistics, a cloud band must intersect at least 20 consecutive parallels of south latitude and must average at least 5° latitude in width. In this way, only the most marked bands were recorded. All quasi-zonal bands, in particular those associated with the sectors of the intertropical convergence zone (ITCZ) sometimes located south of the Equator (Kornfield et al. 1967, Gruber 1972), that do not extend over a wide latitude range are excluded, as are those zonal bands sometimes found close to Antarctica. Figure 2 shows an example of a 5-day-averaged mosaic and the band axes ascribed to it.

A complication exists in a zone of varying width lying between 70° and 90°E associated with the "daybreak" in the hemispheric data. The mosaics in this region are often difficult to assess, but the continuity and orientation of bands across the area frequently enable a cloud band to be delineated with some degree of confidence. Unfortunately, as will be seen later, this particular region is one of considerable interest in the seasonal variation of highest frequency of Indian Ocean cloud bands.

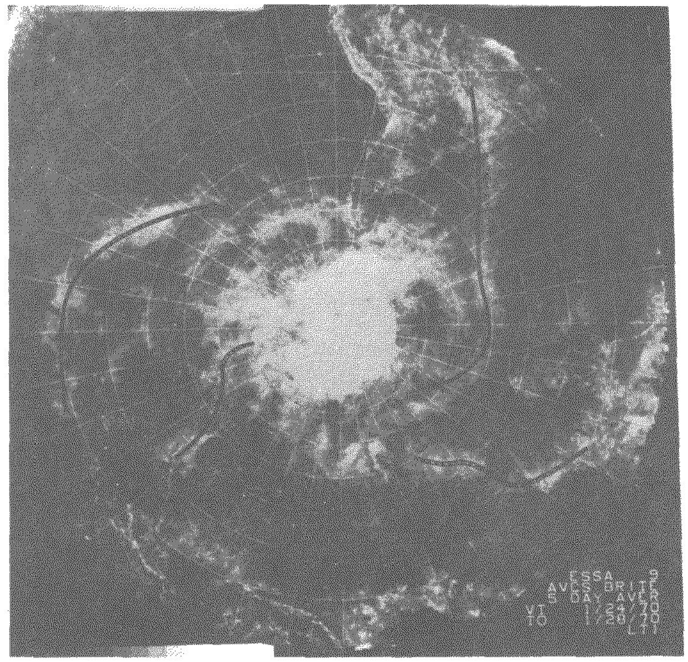

FIGURE 2.—Five-day-averaged brightness mosaic with axes of major cloud bands delineated by superimposed lines.

4. GEOGRAPHICAL FREQUENCY OF 5-DAY-AVERAGED BANDS

The frequency of occurrence of the bands based on 3-yr data is given in figure 3 for four periods—summer (December–March), "intermediate season" (April, May, October, November), winter (June–September), and annual. The data are expressed as a percentage of mosaics having axes of brightness maxima located within a 5° latitude by 10° longitude sector of the polar stereographic projection map. Several main features are apparent.

1. The distinct triple maxima of summer compared with the more complicated pattern in the intermediate and winter months over the Indian Ocean and Australasian region.
2. The high frequencies in all seasons over the South Pacific and South Atlantic. These are consistent with the depression tracks and frequency of cyclogenesis in summer (Streten and Troup 1973) and with the typical cyclone tracks of the International Geophysical Year (IGY) (Taljaard 1967). It is interesting to note that as early as 1930, on the basis of a wind analysis by Köppen, Bergeron (1930) located a winter frontal zone in the South Pacific closely approximating the axis of the high cloudiness region now observed by satellite.
3. The apparent more westward location of the South Atlantic maximum in winter and the higher frequencies in the eastern as compared with the western part of the Indian Ocean in the same season.
4. The apparent secondary maxima appearing at lower latitudes off the west coasts of South America and South Africa in winter. These are clearly associated with the stratus and fog forming in the region of the Peru and Benguela Currents and are more prominent in the colder months.

Individual seasonal maps (not reproduced) show great similarity to the 3-yr averages of figure 3. If the axes of maximum and minimum band frequency are drawn for the 9 individual seasons of the sample period for the region south of 20°S, a pattern is established that enables us to draw envelopes of these axes for particular geographical areas (fig. 4).

Prominent high-frequency axes lie from northwest to southeast across the South Pacific and South Atlantic, falling within narrow bounds. Equally prominent regions of very low band frequency are enclosed by relatively narrow envelopes over the southeast Pacific and South-West Africa. Over the Indian Ocean and Australasia, the band frequency is more complex. The Indian Ocean envelope is much broader in extent than that of the Pacific and Atlantic with a much weaker detached secondary maximum evident over south and east Australia. Such a pattern is, in general, consistent with the location of the ridges of standing waves 1 and 3 found by van Loon and Jenne (1972) in the annual 500-mb map. The pattern over Australasia points to this region as being the major location of change and readjustment in the band pattern.

5. SPATIAL AND TEMPORAL VARIATION OF BAND FREQUENCY

Before discussing the individual characteristics of the bands over particular ocean areas, some statistical features of the band patterns as a whole will be presented.

Band Number

The number of bands ("band number") on a particular 5-day-averaged mosaic ranges from 0 to 7. As shown in figure 5, however, there is a predominance of band

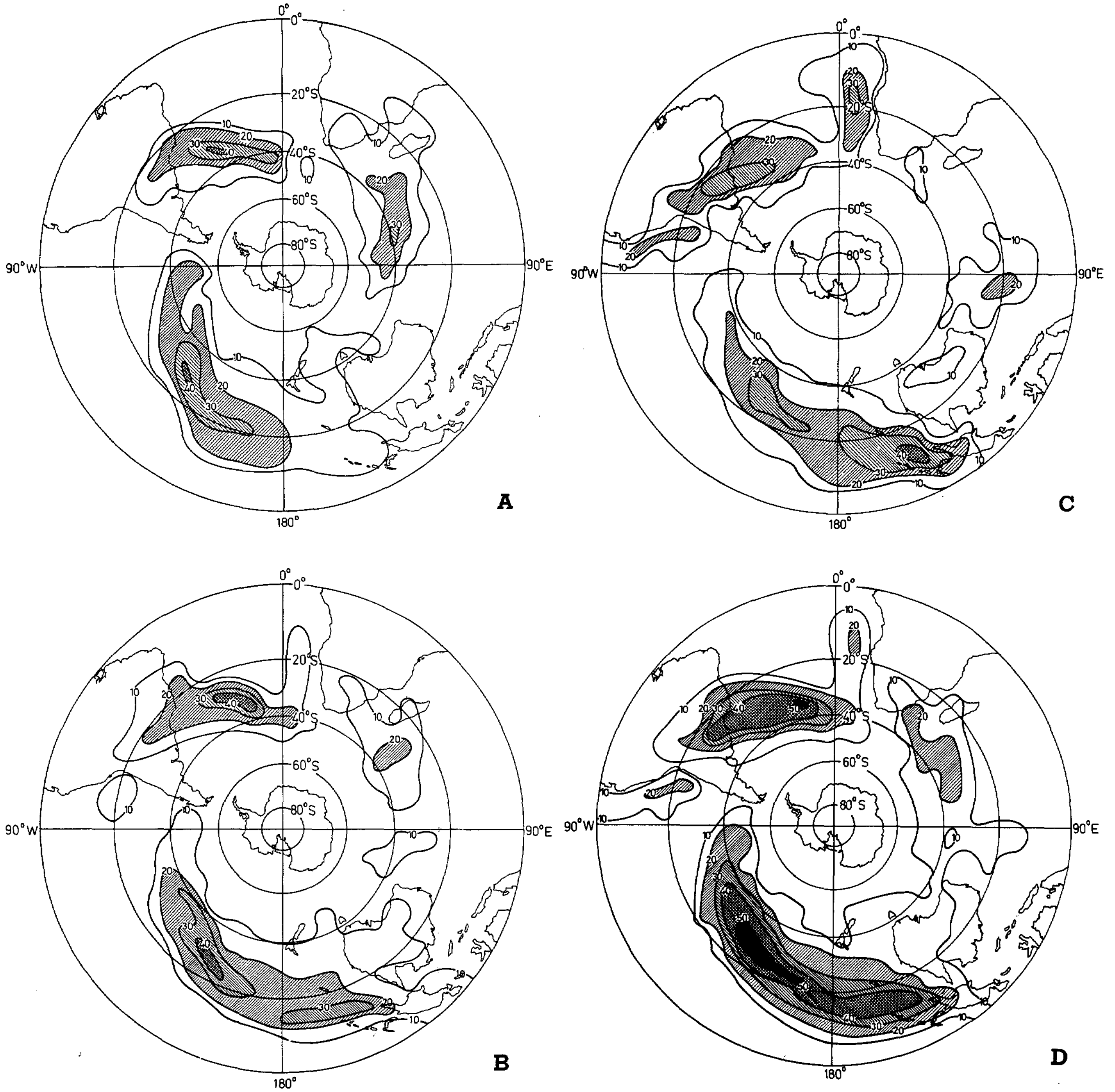

FIGURE 3.—Percentage frequency of 5-day-averaged mosaics having axes of major cloud bands within a 5°-latitude by 10°-longitude square for (A) summer (December–March), (B) intermediate season (April, May, October, November), (C) winter (June–September), and (D) annual. Data based on period November 1968–October 1971.

numbers 3 and 4 averaged over the latitude band from 20° to 50°S, with band number 4 predominating from 30° to 40°S. This pattern may be compared with the statistical analysis of 500-mb data for 1960–61 (Noar 1973), which indicated that wave number 4 was a principal mode of the broad-scale Southern Hemisphere circulation, and with the four-wave pattern in the 700-mb mean monthly trough and ridge locations at 40°S for the period January to May of 1967 (Staver 1969).

The number of bands at particular latitudes on individual 5-day mosaics also displays some monthly variation. Figure 6 indicates the percentage of the total number of mosaics in each month having a band number ≥ 4 averaged over latitudes 20°, 30°, and 40°S. The period with the smaller percentages is clearly in midsummer to early autumn and the highest values occur in late winter and spring. An apparent increase occurs in May with low frequencies in June and July. However, the midwinter period data must be regarded with some caution as the observations are then of lower quality.

Longitude of Maximum Band Frequency

More detailed information on the location of the cloud bands may be obtained by plotting in time section the

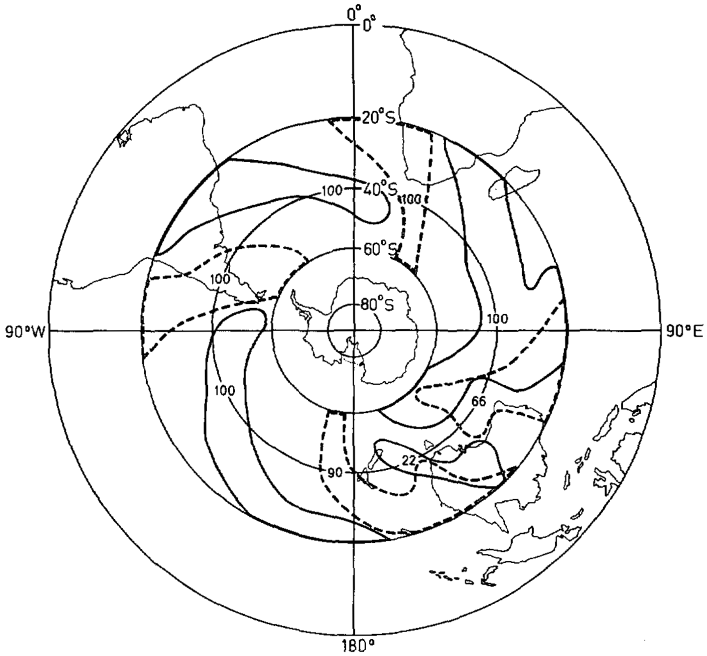

FIGURE 4.—Envelopes of axes of maximum (solid line) and minimum (broken line) frequency of cloud bands for the 9 seasons (3-yr) between 20° and 60°S. Figures along 40°S are percentages of seasons having maxima (minima) within each envelope.

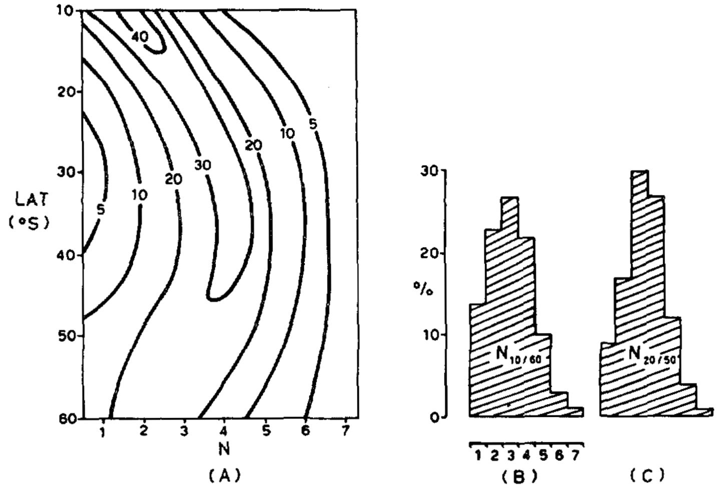

FIGURE 5.—Percentage frequency of (A) the number of cloud bands on individual mosaics (band number N) at particular latitudes, (B) the particular band numbers averaged at 10°-latitude intervals over the range 10°–60°S, and (C) the particular band numbers averaged at 10°-latitude intervals over the range 20°–50°S. Data for November 1968–October 1971.

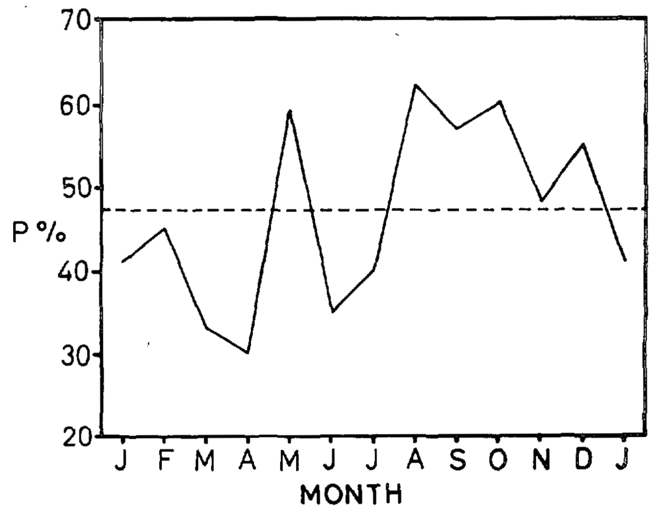

FIGURE 6.—Monthly percentage frequency of mosaics (3-yr data) having band number ≥4 (solid line). The broken line is the annual average.

monthly median longitude at which band axes intersect particular parallels of latitude. Figure 7 shows such data averaged between 30° and 40°S intersections for four separate zones; that is, the South Pacific (170°–70°W), the South Atlantic (70°W–20°E), the Indian Ocean (20°–120°E), and Australasia (120°E–170°W). The boundary longitudes are those at which the band frequency approaches a minimum at midlatitudes. The longitudes are shown as an averaged annual cycle based on the 3-yr data and as median monthly positions in time section for the whole observation period.

Interperiod Displacement of Bands

Examining the mosaics period by period, we observed that the interperiod movement of the most prominent cloud bands is usually fairly regular and a sequence can often be followed as with daily cloud mosaics or synoptic charts. Where at least three successive 5-day-averaged mosaics were available and displayed well-defined bands, the interperiod longitudinal displacement of the bands at a number of latitude intersections was calculated. There are, of course, many situations when no such clear pattern occurs. To some extent, therefore, the calculated motions are biased toward periods where distinct patterns are displayed. Despite this subjective element, we believe that the results represent a reasonable approximation to the motion pattern. The distributions of such movement data are shown for the previously defined zones at latitude 40°S for the whole period (fig. 8), for particular months at latitude 40°S based on all zones (fig. 9), and as a function of latitude (fig. 10).

In general, eastward interperiod movement tends to predominate at all latitudes (fig. 10); westward displacement is more frequent in early autumn and winter (fig. 9). It should be noted that the displacements of figure 10 are shown in terms of degrees of longitude measured on the polar stereographic projection of the mosaic. Further, the angle of intersection of the bands with the latitude parallel, α, is generally smaller at low latitudes than that at higher latitudes, where the bands are more meridionally alined. Thus, small changes in band orientation at 20°S, for instance, may indicate a large, apparent displacement along the latitude circle. Typical values of α are shown in figure 10.

6. BAND CHARACTERISTICS IN RELATION TO LONG- AND SHORT-TERM HEMISPHERIC CIRCULATION FEATURES

Since the behavior of the bands within particular zones with regard to seasonal and longer term location is different, each will be examined separately.

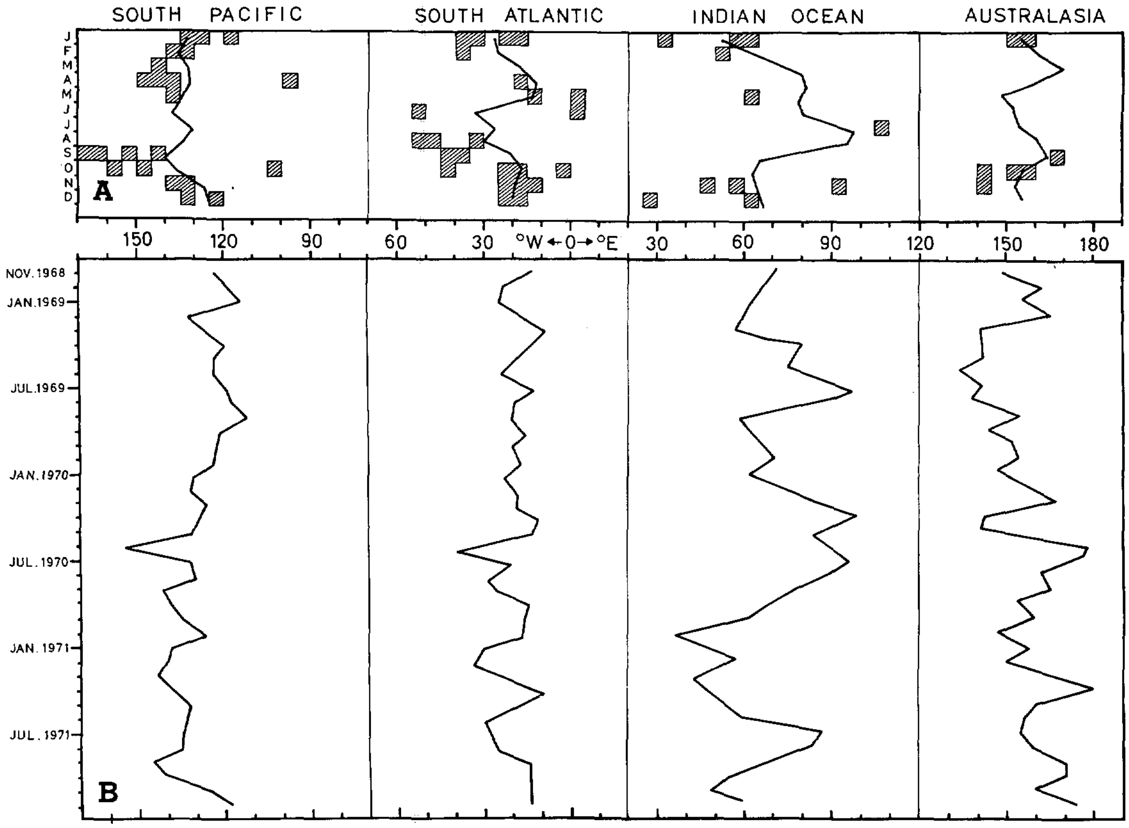

FIGURE 7.—(A) 3-yr average and (B) time section of monthly median longitude of 5-day-averaged bands for four geographical sectors averaged between 30° and 40°S. The shaded squares in (A) indicate months and regions with band frequency $\geq$ 1 per mo at either 30° or 40°S.

The South Pacific Zone

The median location of the Pacific band axes at midlatitudes moves little from month to month (figs. 3, 7A), and the permanence of this broad-scale feature is reflected in the limited longer term climatological data that are available (Streten ..970). However, figure 7B indicates a slow trend in the band axis toward the west from the spring of 1969 to that of 1971, the movement being about 10°–20° of longitude during this period. There is some confirmation of this movement in rainfall data for two island stations, Rapa (27°S, 144°W) and Pitcairn (25°S, 130°W), which are given in table 1. The rainfall at Rapa is slightly above the long-term average during the period, but, as the band position tends to lie increasingly west of Pitcairn Island, this station records many very dry months with a large overall rainfall deficit. This situation is probably associated at least in part with the westward displacement of highest band frequency.

Figure 8 indicates largely eastward interperiod displacements at 40°S, the westward movement being of lower frequency and smaller magnitude.

The South Atlantic Zone

The median location of the bands in the Atlantic is between 15° and 25°W in the latitude zone from 30° to 40°S (fig. 7). A band is prominent in most multiday imagery extending southeastward across the ocean. In the mean (fig. 7A), there is some indication of a more

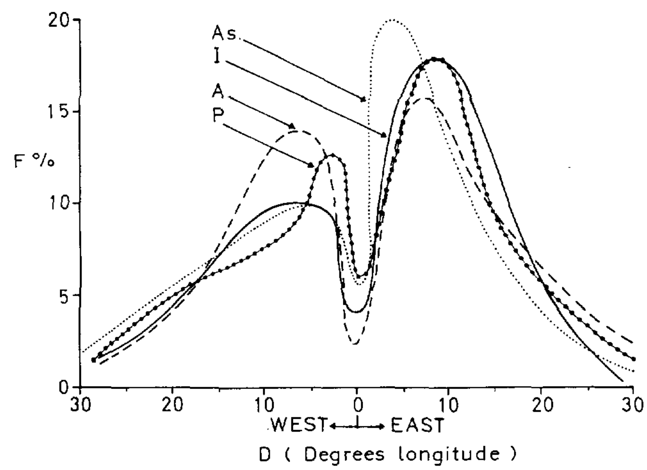

FIGURE 8.—Percentage frequency distribution of longitudinal displacement of cloud bands at 40°S between successive 5-day-averaged mosaics for the Atlantic Ocean (A), Australasia (As), the Indian Ocean (I), and the Pacific Ocean (P).

TABLE 1.—*Rainfall Data for South Pacific Islands from October 1969 to September 1971*

Station	$P(p)$	N_1	N_2
Rapa	+6(2893)	6	4
Pitcairn Is.	−18(1830)	2	9

P is the percentage departure of rainfall total from long-term mean p (mm).
N_1 is the number of months with rainfall $\geq$50 percent above normal.
N_2 is the number of months with rainfall $\leq$50 percent below normal.

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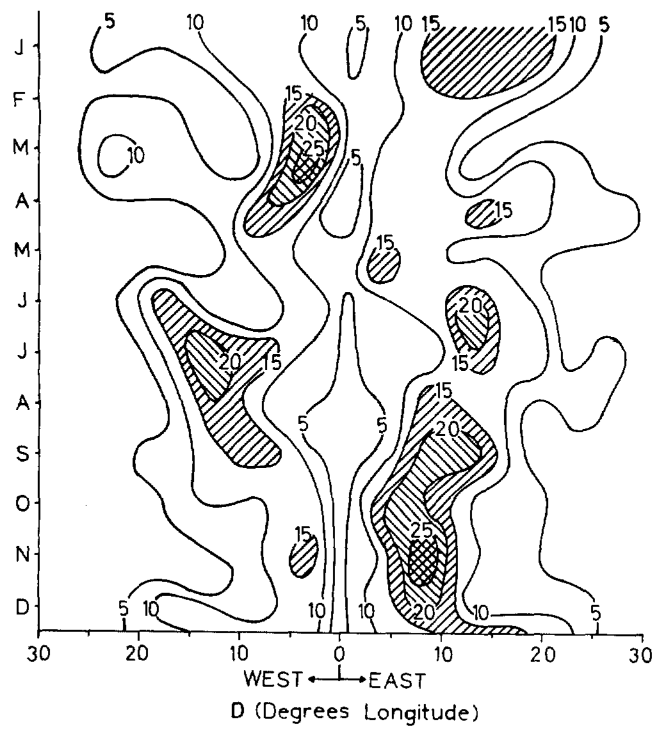

FIGURE 9.—Percentage frequency distribution of longitudinal displacement of cloud bands at 40°S between successive 5-day-averaged mosaics as a function of time (month) based on 3 yr of data for the whole hemisphere.

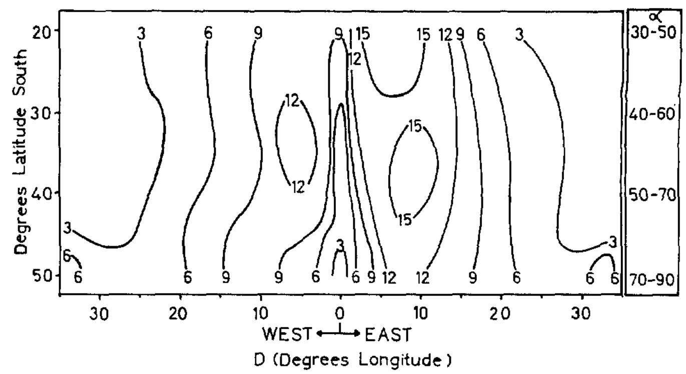

FIGURE 10.—Percentage frequency distribution of longitudinal displacement of cloud bands between successive 5-day-averaged mosaics as a function of latitude based on 3 yr of data for the whole hemisphere. Column on the right shows typical values of α, the angle of intersection of the cloud bands with the latitude parallel.

westerly location in winter at midlatitudes. Such a westward location in this season appears to be consistent with the winter synoptic situations on the Brazilian east coast. (Trewartha 1962), particularly with the secondary frontogenesis and the patterns of coastal winter rainfall at low latitudes in the region described by this author. The high winter cloudiness in the coastal region is further revealed in the data given by Miller and Feddes (1971).

The interperiod movement of the bands at 40°S (fig. 8) is more symmetric in the South Atlantic than elsewhere with the distribution showing peaks at from 5° to 10° of longitude in both east and west displacement.

The Indian Ocean Zone

This sector displays a substantial (30°–40° longitude) seasonal variation in the median location of the band from the western part of the ocean in January eastward to the vicinity of 90°E in late winter (fig. 7A) with a transition occurring in the mean, quite rapidly in spring. Despite the previously discussed difficulty in assessing the data in this area, the displacement was similar in all 3 yr (fig. 7B), and the pattern appears to be real.

Van Loon (1971) indicates a midlatitude association between the location of the speed maximum in the sea-surface current and that of the center of the mean subtropical High over the Indian Ocean, both being farther east in summer and west in winter. The variation in the location of the anticyclone is further confirmed by the total cloudiness pattern revealed in the 4-yr data of Miller and Feddes (1971).

The band location is in opposite phase to that of the anticyclone. In summer, the band most frequently extends from tropical Africa and Madagascar southeastward into the ocean to the west of the High. In winter, when the anticyclone is located farther west, the median position of the cloud bands is to the west of Australia in longitudes 85° to 95°E. In the latter season, another band is often located to the west of the High (fig. 3C), but with lower frequency than that near 90°E.

The westward location of the median position of the band in summer is consistent with the analysis of Lamb (1959), who concluded that the summer movement of the broad trough in the Indian Ocean westward to about 60°E was the only recognizable seasonal shift in the trough ridge pattern that could be inferred from conventional observations for the entire hemisphere. Other investigators (e.g., Noar 1973), however, have found evidence for a westward displacement in winter. The present data appear to imply substantial frequencies of troughs in both the eastern and western parts of the ocean in winter, but with troughs in the east predominating.

It may be significant that, in summer, frequent advection of moist air is occurring from tropical Africa southeastward along the longitudes of the prominent band. In winter, advection of tropical maritime air frequently occurs to the west of large, detached high-pressure systems centered over Australia. However, at this time, drier air from continental southern Africa may be translated over southern waters westward of the principal oceanic anticyclone resulting in less-prominent cloud band development. The striking differences in the cloud cover statistics from summer to winter over southern Africa are evident in the seasonal data of Miller and Feddes (1971). Examination of interperiod displacement data (fig. 8) indicates a predominance of 5°- to 10°- longitude movements to the east at 40°S.

The Australasian Zone

The bands in this region are less frequent and well-defined than those over the major ocean areas (figs. 3, 4).

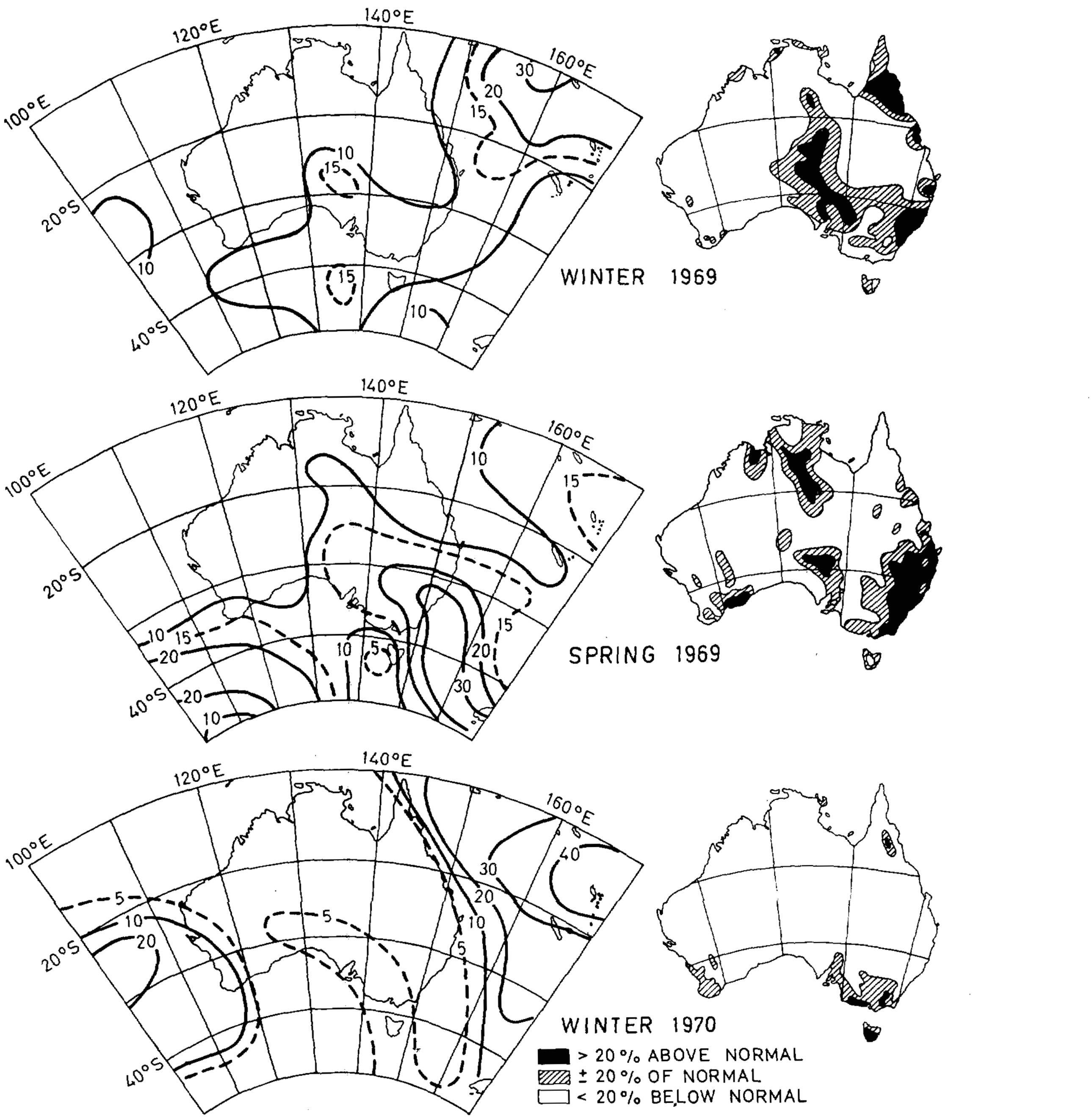

FIGURE 11.—Relative cloud band frequency and corresponding rainfall departure from normal for specific seasons in the Australian region.

Although the variation in monthly location is not notable, the bands appear, in median position, to be farther west in winter at the time of the farthest eastward displacement of the Indian Ocean band (fig. 7). Thus, the distance between the two bands is at a minimum at that season. There is some indication of a slight eastward trend during the 3-yr period (fig. 7B), thus shortening the distance between the Australasian and South Pacific bands. Interperiod displacements showing a maximum frequency eastward of less than 5° of longitude are smaller than in the other zones.

In the colder months, the rainfall over much of Australia, particularly the southern half, results from the passage of active depressions over the waters south of the continent. The associated frontal bands (often displaying lower latitude secondary developments) traverse the continent from west to east with varying rates of motion and frequent stagnation in particular areas. Examination of the data on the frequency of 5-day-averaged bands for individual seasons indicates considerable qualitative similarity between the pattern of seasonal rainfall anomaly and that of band frequency. Figure 11 shows these corresponding patterns for 3 seasons. The relative band frequencies are shown in terms of the percentage of 5-day-averaged mosaics having a band axis located within the appropriate 5°-latitude by 10°-longitude square. Rainfall departure from normal is shown as derived from the reporting network of the Australian Bureau of Meteorology (1969–1970). It appears that even such a crude measure of the frequency of organized cloud as the "band frequency" employed here may be able to provide inferences to broad-scale seasonal anomalies of precipitation over the middle latitudes of the southern oceans.

Some steps toward a more quantitative assessment of climatological rainfall patterns from satellite data have been taken (e.g., Barrett 1970), and the utilization of digitized brightness data in conjunction with some measure of cloud organization such as the frequency of 5-day-averaged bands may enable broad working relationships to be derived.

7. CONCLUDING REMARKS

In general, the bands at 30°–40°S include an apparent half yearly component in the annual march of their median longitude (fig. 7A). This half yearly component is in the sense that when the subantarctic trough moves poleward (van Loon 1967) the bands, on the average, tend to move eastward; when the trough moves equatorward, the bands tend to move westward. This movement is not evident in the Pacific zone, however, possibly because the trough is about 7°–10° farther poleward in this region.

In this description of the frequency of 5-day-averaged cloud bands and the interperiod, seasonal, and longer term characteristics of their motion, the principal results are as follows:

1. The band pattern is found to display a high frequency of band numbers 3 and 4. This is in general agreement with the analyses of the modes of long-wave pattern for the hemisphere as deduced from conventional data.
2. In contrast to the relatively stable median monthly locations in the South Pacific and South Atlantic, bands over the Indian Ocean display a large variation in position from summer to winter. Such locations are in opposite phase to those of the centers of Highs over the ocean and to the maxima of ocean surface current speed.
3. Apparent long-term westward motion of the median location of the Pacific bands between 1969 and 1971 are reflected in the rainfall pattern at Rapa and Pitcairn Islands.
4. Qualitative pattern agreement is found between the frequency of bands and the rainfall anomaly over continental Australia for three colder month seasons.

The nature of the midlatitude band structure is still uncertain. However, the evidence suggests that their location is, in general, related closely to that of the long-wave hemispheric pattern. It is notable that the three more distinct low-latitude termini of high band frequency are located over Africa, South America, and, in particular, the eastern tip of New Guinea—the eastern extremity of the so called "maritime continent". The bands may thus visually represent the mean channels wherein energy flow occurs into the midlatitude westerlies from these tropical-continental areas of most active convection. It is interesting that ATS 3 pictures for the South American region give a distinct impression of the movement of cloud features from the tropical Amazon region southeastward into the persistent cloud band over the South Atlantic. The mean bands may thus be climatologically analogous to the bands connected with particular tropical cyclones, studied by Erickson and Winston (1972), as channels of poleward energy transfer.

Hopefully, we may, in the near future, be able to test and numerically reproduce the satellite-observed features of the circulation described here by general circulation models of the Southern Hemisphere currently being developed in Australia.

ACKNOWLEDGMENTS

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REFERENCES

Australian Bureau of Meteorology, Department of Interior, *Seasonal Weather Review—Australia*, Winter 1969, Spring 1969, Winter 1970, Melbourne, **1969–1970**.

Barrett, Eric C., "The Estimation of Monthly Rainfall From Satellite Data," *Monthly Weather Review*, Vol. 98, No. 4, Apr. **1970**, pp. 322–327.

Bergeron, Tor, "Richtlinien einer Dynamischen Klimatologie," *Meteorologische Zeitschift*, Vol. 47, No. 7, Braunschweig, Germany, July **1930**, pp. 246–262.

Booth, Arthur L., and Taylor, V. Ray, "Mesoscale Archive and Computer Products of Digitized Video Data From ESSA Satellites," *Bulletin of the American Meteorological Society*, Vol. 50, No. 6, June **1969**, pp. 431–438.

Erickson, Carl O., and Winston, Jay S., "Tropical Storm, Mid-Latitude, Cloud-Band Connections and the Autumnal Buildup of the Planetary Circulation," *Journal of Applied Meteorology*, Vol. 11, No. 1, Feb. **1972**, pp. 23–36.

Gruber, Arnold, "Fluctuations in the Position of the ITCZ in the Atlantic and Pacific Oceans," *Journal of the Atmospheric Sciences*, Vol. 29, No. 1, Jan. **1972**, pp. 193–197.

Holl, Manfred M., "A Diagnostic-cycle Routine," *Final Report*, Contract Cwb 10314, Meteorology International Inc., Monterey, Calif., Feb. **1963***a*, 37 pp.

Holl, Manfred M., "Scale and Pattern Spectra and Decompositions," *Technical Memorandum* No. 3, Contract N228–(62271) 60550 Meteorology International Inc., Monterey, Calif., Nov. **1963***b*.

Kornfield, J. A., Hasler, A. F., Hanson, K. J., and Suomi, V. E., "Photographic Cloud Climatology from ESSA III and V Computer Produced Mosaics," *Bulletin of the American Meteorological Society*, Vol. 48, No. 12, Dec. **1967**, pp. 878–883.

Lamb, Hubert H., "The Southern Westerlies: A Preliminary Survey: Main Characteristics and Apparent Associations," *Quarterly Journal of the Royal Meteorological Society*, Vol. 85, No. 363, London, England, Jan. **1959**, pp. 1–23.

Leese, John A., Booth, Arthur L., and Godshall, Frederick A., "Archiving and Climatological Applications of Meteorological Satellite Data," ESSA *Technical Report* NESC 53, Washington, D.C., July **1970**, section 3, 23 pp.

Miller, Donald B., and Feddes, Robert G., "Global Atlas of Relative Cloud Cover 1967–70 Based on Photographic Signals From Meteorological Satellites," NOAA (NESS)/USAF (Air Weather Service-MAC) *Joint Production*, Washington, D.C., Sept. **1971**, 237 pp.

Nagle, Roland E., and Hayden, Christopher M., "The Use of Satellite-Observed Cloud Patterns in Northern-Hemisphere 500-mb. Numerical Analysis," NOAA *Technical Report* NESS 55, Washington, D.C., Apr. **1971**, 25 pp.

Noar, Peter F., "Energy Dispersion and Other Features of the Middle Latitude Circulation of the Australian Region," *Meteorological Study* No. 24, Australian Bureau of Meteorology, Melbourne, Feb. **1973**, 96 pp.

Riegel, Christopher A., "An Interpretation of Holl's Inherent Scale Techniques," Meteorology International Inc., Monterey, Calif., Mar. **1965**, 18 pp.

Saha, Kshudiram, "Mean Cloud Distributions Over Tropical Oceans," *Tellus*, Vol. 23, No. 2, Stockholm, Sweden, **1971**, pp. 183–195.

Staver, Allen E., "Dynamic Characteristics of the Southern Hemisphere's Circumpolar Vortex and a Comparison With its Northern Hemisphere Counterpart," Ph.D. thesis, University of Wisconsin, University Microfilms Inc., Ann Arbor, Mich., Jan. **1969**, 113 pp.

Streten, Neil A., "Some Aspects of High Latitude Southern Hemisphere Summer Circulation as Viewed by ESSA 3," *Journal of Applied Meteorology*, Vol. 7, No. 3, June **1968***a*, pp. 324–332.

Streten, Neil A., "A Note on Multiple Image Photo-Mosaics for the Southern Hemisphere," *Australian Meteorological Magazine*, Vol. 16, No. 4, Melbourne, Dec. **1968***b*, pp. 127–136.

Streten, Neil A., "A Note on the Climatology of the Satellite Observed Zone of High Cloudiness in the Central South Pacific," *Australian Meteorological Magazine*, Vol. 18, No. 1, Melbourne, Mar. **1970**, pp. 31–38.

Streten, Neil A., and Troup, A. J., "A Synoptic Climatology of Satellite Observed Cloud Vortices Over the Southern Hemisphere," *Quarterly Journal of the Royal Meteorological Society*, Vol. 99, No. 419, London, England, Jan. **1973**, pp. 56–72.

Taljaard, J. J., "Development, Distribution and Movement of Cyclones and Anticyclones in the Southern Hemisphere During the IGY," *Journal of Applied Meteorology*, Vol. 6, No. 6, Dec. **1967**, pp. 973–987.

Taljaard, J. J., van Loon, H., Crutcher, H. L., and Jenne, R. L., *Climate of the Upper Air Part 1—Southern Hemisphere*, U.S. Navy NAVAIR 50-1C-55, Vol. 1, Washington, D.C., Sept. **1969**.

Trewartha, Glen T., *The Earth's Problem Climates*, University of Wisconsin Press, Madison, Methuen & Co., London, **1962**, 334 pp. (See pp. 41–56.)

van Loon, Harry, "The Half-Yearly Oscillations in Middle and High Southern Latitudes and the Coreless Winter," *Journal of the Atmospheric Sciences*, Vol. 24, No. 5, Sept. **1967**, pp. 472–486.

van Loon, Harry, "A Half Yearly Variation of the Circumpolar Surface Drift in the Southern Hemisphere," *Tellus*, Vol. 23, No. 6, Stockholm, Sweden, **1971**, pp. 511–516.

van Loon, Harry, and Jenne, Roy L., "The Zonal Harmonic Standing Waves in the Southern Hemisphere," *Journal of Geophysical Research*, Vol. 77, No. 6, Feb. 20, **1972**, pp. 992–1003.

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